

majority of experiments, corresponding with the following conditions and in this decreasing order :

- (1) Basal medium + juice of effectively nodulated root ;
- (2) Basal medium + juice of uninoculated root ;
- (3) Basal medium + juice of ineffectively nodulated root.

However, there is no evidence to show that the nutritive substances of the yeast sucrose medium were such as to support maximum growth, namely, growth which could not be improved by extra nutrients in the medium. In fact, the one experiment which reports results with water instead of plant juices showed that the latter, even from poorly nourished uninoculated plants, caused considerable increase in growth :

Mean growth, all strains	Mean Colony Areas (sq. mm.)	
	Without root juices	With juices from uninoculated plants
	99.7	137.3

The possibility remains, therefore, that the stimulation in (1) over (2) is nothing more than the effect of an abundant nutritive supplement : a result of the effective association and not its cause.

The superior growth made in (2) compared with (3) might, at first glance, argue a case for inhibitory substances produced by the ineffective association. However, in the one comparison reported the growth in the medium containing the "ineffective" juice was no worse than that on unsupplemented medium. On theoretical grounds, it seems not unreasonable to expect the juices from roots carrying an ineffective strain to be relatively impoverished even in comparison with uninoculated controls. The parasitic organisms might well have tied up in their bodies the small amount of nutrients which would have been otherwise available to the cultivated bacteria. Again it is possible to regard the observed effect as a result and not the cause of the nature of the association.

It would seem then that, whilst the results presented in the paper are compatible with the hypothesis postulated by the authors, they do not offer sound evidence in support. At the most they seem to have shown that the root juice of an effectively nodulated plant is a better nutrient than that of an impoverished control which is, in turn, better than that of a plant the nutrients of which have already been largely utilized by parasitic bacteria.

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MR. VINCENT, who courteously sent me a copy of this letter before publication, suggests that the juice from roots bearing effective nodules is more stimulating to the growth of *Rhizobium* as a result of effective association. This is in agreement with our views. We state in our paper¹ (p. 489) that there is evidence of "an increased stimulating effect from juices of roots bearing effective nodules, possibly connected with the products of nitrogen fixation".

Mr. Vincent makes the further interesting suggestion that the poor growth of *Rhizobium* on medium containing juice from plants having ineffective nodules is in reality a deficiency effect, due to the removal by the bacteria in the nodule of nutrients present in the juice of uninoculated roots. The basal medium was supplied with mineral salts and carbohydrates in

amounts shown by cultural tests to be in excess of the bacterial needs. Thus the stimulating action of juice from uninoculated roots was probably due either to nitrogen or to accessory growth substances. The following data were obtained from a pot experiment in which soy beans were grown in sand under conditions similar to those used to obtain the material for our root juice experiments with this plant.

Soy Beans	Nitrogen %	Nitrogen content per plant (mgm.)	Number of nodules per plant
Without nodules	1.45	16.69	—
With ineffective nodules (Strain 507)	1.73	19.34	45

The presence of ineffective nodules did not reduce the nitrogen percentage of the plants, so that it seems unlikely that the root juice will have been seriously impoverished in this respect. The root juice in our experiments included nodule juice. Some nitrogen may therefore have been locked up in the cells of bacteria retained by the filter. A calculation was made of the total volume of infected nodule cells per plant inoculated with strain 507. This gave 71 mm³. Allowing 20 per cent dry matter with 8 per cent nitrogen this would account for only about 1 mgm. of nitrogen, the loss of which could scarcely affect the nitrogen percentage of the juice. The removal of accessory growth substances by the bacteria is an unsupported possibility. It will not explain the fact that in our first experiment with soy beans (Table I, p. 481) juice from roots bearing ineffective nodules entirely prevented the growth of one strain of the *Rhizobium*. The production, in the infected root, of substances affecting bacterial growth explains this and also accounts for the observation that the bacteria in ineffective nodules multiply less and last for a shorter time than those in effective nodules. This poor growth occurs in spite of the fact that the nitrogen fixed per unit mass of bacterial tissue per day is the same for the ineffective strain 507 as for an effective strain².

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¹ Chen, H. K., Nicol, Hugh and Thornton, H. G., *Proc. Roy. Soc.*, B, **129**, 475 (1940).

² Chen, H. K., and Thornton, H. G., *Proc. Roy. Soc.*, B, **129**, 208 (1940).

Specific Heat of Supra-Conductive Tantalum

THE behaviour of supra-conductive tantalum is far from clear. Early magnetic and electric experiments by Mendelssohn and Moore¹, and a more recent determination of the specific heat by Keesom and Désirant², indicated that pure tantalum showed properties very similar to a supra-conductive alloy³. Further magnetic experiments by Daunt and Mendelssohn⁴ on a very pure sample, however, yielded results consistent with those obtained on other pure supra-conductors.

In order to clear up this discrepancy, it was decided to carry out measurements of the specific heat on very pure samples in the supra-conductive and in the normal state. These experiments were begun in 1939 by Dr. M. Désirant, of the University of Liège, and myself at this Laboratory, but had to be discontinued at the outbreak of war. By then all measurements in the supra-conductive state had been completed. As there is no prospect of resuming this research in the near future, we feel justified in publishing a short account of these results.